DC MOTOR SPEED CONTROLLER

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ABSTRACT

The automatic control has played a vital role in the advance of engineering and science. Nowadays in industries, the control of direct current (DC) motor is a common practice thus the implementation of DC motor of controller speed is important. The main purpose of motor speed control is to keep the rotation of the motor at the preset speed and to drive a system at the demanded speed. When used in speed application, speed feedback control the DC motor's speed or confirms that the motor is rotating at the desired speed. To maintain the speed, it requires the speed feedback at all times. The speed of a DC motor usually is directly proportional to the supply voltage. For instance, if we reduce the supply voltage from 12 Volts to 6 Volts the motor will run at half or lower the speed. The advantages used DC motor is provide excellent speed control for acceleration and deceleration with effective and simple torque control. The fact that the power supply of a DC motor connects directly to the field of the motor allows for precise voltage control, which is necessary with speed and torque control applications. The common methods are used to control speed DC motor is Proportional Integral Derivative (PID) and PC based to control it. In this project, the method use as controller is Programmable Interface Controller (PIC) microcontroller for the electric current control to drive a motor. The expectation of this project is to get the precise the demanded speed and to drive a motor at that speed.

ABSTRAK

Kawalan automatik telah memainkan peranan penting dalam kemajuan ilmu sains dan kejuruteraan. Pada masa kini di industri, kawalan motor arus terus (AT) adalah amalan umum sehingga pelaksanaan kawalan kelajuan motor AT adalah penting. Tujuan utama dari kawalan kelajuan motor adalah menjaga pusingan motor pada kelajuan preset dan untuk memacu sistem di kelajuan diigini. Apabila digunakan dalam aplikasi kelajuan, kelajuan kawalan suap balik kelajuan motor AT atau menegaskan bahawa motor sedang berputar pada kelajuan yang dikehendaki. Untuk mempertahankan kelajuan, memerlukan maklum balas kelajuan bila-bila masa. Kelajuan motor AT biasanya berbanding lurus dengan tegangan bekalan. Sebagai contoh, jika kita mengurangkan bekalan voltan daripada 12 Volt ke 6 Volts motor akan berjalan pada setengah atau lebih rendah kelajuan. Kebaikan yang digunakan adalah motor AT memberikan kawalan kelajuan yang sangat baik untuk percepatan dan perlambatan dengan kawalan torsi berkesan dan sederhana. Fakta bahawa bekalan elektrik dari motor AT berhubung langsung dengan bidang motor membolehkan kawalan voltan yang tepat, yang diperlukan dengan aplikasi kawalan kelajuan dan torsi. Kaedah yang umum adalah digunakan untuk mengawal kelajuan motor DC adalah Proportional Integral Derivatif (PID) dan PC berasaskan mengendalikannya. Dalam projek ini, penggunaan kaedah sebagai pengendali adalah Programmable Interface Controller (PIC) mikropengawal untuk mengawal arus elektrik untuk menggerakkan motor. Harapan dari projek ini adalah untuk mendapatkan kelajuan yang tepat menuntut dan menggerakkan motor pada kelajuan itu.

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LIST OF SYMBOLS

K_g	-	A constant based on motor construction
Φ	-	Magnetic flux
I_f	-	Field current
I_a	-	Armature current
R_f	-	Field resistor
L_f	-	Field inductor
K_v	-	Motor constant
K_f	-	Torque constant
T_d	-	Developed torque
T_L	-	Load torque
B	-	Viscous friction constant
J	-	Inertia of the motor
ω	-	Motor speed
t_{on}	-	Time ON of switches
T	-	Period

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CHAPTER 1

INTRODUCTION

1.1 Background

The direct current (DC) motor is a device that used in many industries in order to convert electrical energy into mechanical energy. This is all result from the availability of speed controllers is wide range, easily and many ways. In most applications, speed control is very important. For example, if we have DC motor in radio controller car, if we just apply a constant power to the motor, it is impossible to maintain the desired speed. It will go slower over rocky road, slower uphill, faster downhill and so on. So, it is important to make a controller to control the speed of DC motor in desired speed.

DC motor plays a significant role in modern industry. The purpose of a motor speed controller is to take a signal representing the demanded speed, and to drive a motor at that speed. There are numerous applications where control of speed is required, as in rolling mills, cranes, hoists, elevators, machine tools, transit system and locomotive drives. These applications may demand high-speed control accuracy and good dynamic responses.

In home appliances, washers, dryers and compressors are good example. There are many applications in our life that requires DC motor speed control. In conclusion, the simplicity of control speed made DC motors to be common in devices ranging from toys, house appliance and robotics to industrial application.

1.2 Objective of the Project

Basically, these projects are listing three main objectives. The objectives are a guideline and goal in order to complete this project. This project is conducted to achieve the following objectives:

i. To design the hardware of the controller to control DC motor speed.
ii. To develop controller using microcontroller as programming.
iii. To develop precisely control the DC motor.

1.3 Scope of the Project

There are two scopes in this project which is hardware development and software development.

For the first scope which is hardware development are three main sections and those section are:

i. To design a circuit for to control voltage input.
ii. To design a for the motor drive.
iii. To design a circuit for the PIC 16F877.
iv. To design the rectifier circuit.

For the second scope which is the software development, there are two main sections and that section are:

i. To develop a software using the PBasic of the PIC 16F877.
ii. To simulate the control system using Proteus software.

1.4 Problem Statement

The most issue discusses in speed controller is regarding their efficiency and reliability. The efficiency element is important in order to save cost. The efficiency of speed controller is depending on method control system. The speed controller usually control in analog system.

An analog signal has a continuously varying value, with infinite resolution in both time and magnitude. For example, a 5 V is an analog and its output voltage is not precisely 5 V, changes over time, and can take any real-numbered value. Similarly, the amount current drawn from a battery is not limited to a finite set of possible value. Analog signals are distinguishable from digital signals because the latter away take values only from a finite set of predetermined possibilities.

DC motor widely used in speed control systems which needs high control requirement such as rolling mill, double-hulled tanker and high precision digital tools. So, it is crucial to control the motor sped in order to achieve good production. One of the most common methods to drive a DC motor is by using PWM signals respect to the motor input voltage.

Manual controller is also not practical in the technology era because it can waste time and cost. Operation cost regarding controller is got attention from industrial field. In order to reduce cost and time, we suggest making a controller based on computer because it is portable. The user can monitor their system at certain place without need to going the plant (machine) especially in industrial implementation. From that, the man power can be reduced and reserve with computer which is more precise and reliable.

The other product regarding this project where control motor via computer may be commercialized but their cost is very expensive. The hardware of this product may be complicated and maintenance cost is higher. The low cost electronic devices can be designed to make a speed controller system.

1.5 Thesis Outline

This thesis consists five chapters. In first chapter, it discusses about introduction and overview about this project includes background, objectives and scope of projects.

Chapter two is explanations about literature review as study material and references. The topics that I have studied are about the other method of speed control to compare and analysis their advantages and disadvantages. From the literature review, knowledge can be gained thus implement in this project.

The methodology that I have done are discusses on chapter three. This is explanations about the method used to complete hardware and software. Chapter four are discusses of the result and analysis of this project. For the last chapter are describes conclusion and future recommendation to make this project greatly.

This thesis included with references and appendices. We can refer the further information about this project in references which is states the source and their authors. Datasheet of the components, photo and other information also placed on the appendices part.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

There are two main types of electrical motors. There are direct current (DC) motor and alternating current (AC) motor. The reference of DC and AC refers how the electrical current is transferred through and from the motor. Both the types of the motors have different functions and applications. DC motors come in two general types. Its brushes and be brushless (synchronous motor). Then, AC motor come in two types, which is single phase and three phase.

2.2 DC Motor

There are many types of DC motor that are available such as stepper motor, permanent magnet DC (PMDC), printed circuit board (PCB) motor and others. These motors have their own advantages and disadvantages, and are used in different applications. Stepper motor has a very precise speed and position control, it’s also has high torque at low speed. But on the hand, stepper motors are expensive and hard to find. It also requires switching control circuit.

For PMDC motor, it’s smaller since the field windings are replaced by permanent magnet and cheaper as well. The absence of the field winding as well as results to copper loss absent and this increase the efficiency. But PMDC motors also have several disadvantages. There is risk of demagnetization, which may caused by excessive armature current or excessive heating if the motor is overloaded over a prolonged period of time. The speed of PMDC motor cannot be controlled by field flux and thus speed control must be achieved by changing the armature voltage. These motors are therefore used only where motor speeds below base speed are required. They do not offer the flexibility of operation beyond the base speed.

The printed circuit board (PCB) motor, using permanent magnet, has a configuration radically different from that of the conventional DC motor. The entire armature winding and the commutator are printed in PCB disk (rotor). This type of motor has several advantages such as high torque that allows it provides rapid acceleration and deceleration. The motor can accelerate from 0 to 4000 rpm in 10 milliseconds. The motor has no cogging torque because the rotor is nonmagnetic. These motors are particularly suitable for applications requiring high performance characteristics.

There are other types of DC motor that have their own advantages and disadvantages. The variety of DC motor types give a variety of control method and also the variety of application that can be performed. In conclusion, DC motors have many types and differ with each other in characteristics of the motor and also the use the motor in appliances.

There are several types of DC motors that are available. Their advantages, disadvantages and other basic information are list below in the Table 2.1 [1].

2.1: Advantages and disadvantages of various types of DC motor

Type	Advantages	Disadvantages
Stepper Motor	Very precise speed and position control. High torque at low speed.	Expensive and hard to find. Require a switching control circuit.
DC Motor W/field Coil	Wide range of speed and torque. More powerful than permanent magnet motors.	Require more current than permanent magnet motors, since field coil must be energized. Generally haevier than permanent magnet motors. More difficult to obtain.
DC Permanent Magnet Motor	Small. Compact. Easy to find. Very inexpensve.	Generally small. Cannot vary magnetic field strength.

2.3 Model of Separately Excited DC Motor

Figure 2.1 shows a model of separately excited DC motor [2]. When a separately excited motor is excited by a field current, i_f and an armature current, i_a flows in the circuit, the motor develops a back EMF and a torque to balance the load torque at a particular speed. The i_f is independent of the i_a. Each winding are supplied separately. Any change in the armature current has no effect on the field current. The i_f is normally much less than the i_a. The relationship of the field and armature are shown in Equation 2.1.

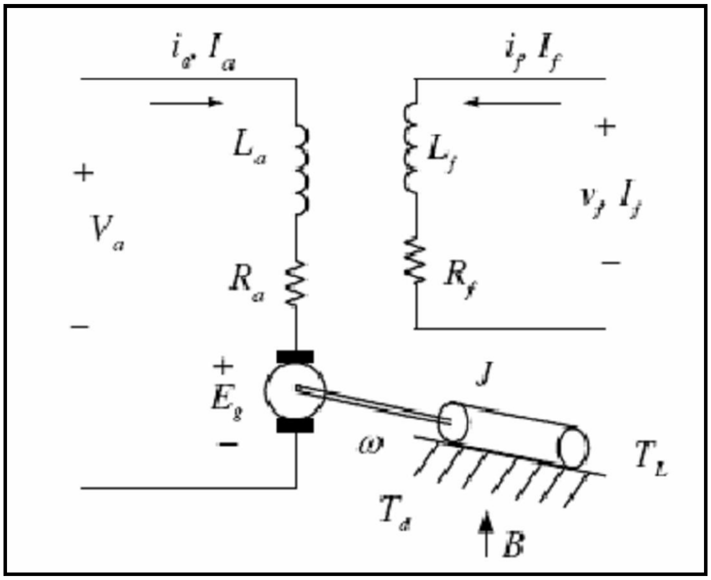

Figure 2.1: Model of separately excited DC motor

The instantaneous field current:

$$V_f = R_f i_f + L_f \frac{di_f}{dt} \tag{2.1}$$

where R_f and L_f are the field resistor and inductor respectively.

The istantaneous armature current:

$$V_a = R_a i_a + L_a \frac{di_a}{dt} + e_g \tag{2.2}$$

where R_a and L_a are the armature resistor and inductor respectively.

The motor back EMF, which is also kwown as speed voltage:

$$e_g = K_v \omega i_f \tag{2.3}$$

where K_v is the motor constant (in V/A-rad/s) and ω is the motor speed (rad/s).

The torque developed by the motor:

$$T_d = K_i i_f i_a \tag{2.4}$$

where ($K_t = K_v$) is the torque constant (in V/A-rad/s).

The developed torque must be equal to the load torque:

$$T_d = J \frac{d\omega}{dt} + B_\omega + T_L \tag{2.5}$$

where B = viscous friction constant, N•m/rad/s

T_L = load torque, N•m

J = inertia of the motor, kg·m^2

Under steady-state operations, a time derivative is zero. Assuming the motor is not saturated.

For field current:

$$V_f = R_f I_f \tag{2.6}$$

The back EMF is given by:

$$E_g = K_v \omega I_f \tag{2.7}$$

The armature circuit:

$$V_a = I_a R_a + E_g = I_a R_a + K_v \omega I_f \tag{2.8}$$

The motor speed can be easily derived:

$$\omega = \frac{V_a - I_a R_a}{K_f I_f} \tag{2.9}$$

If R_a is a small value (which is usual) or when the motor is lightly loaded, i.e. i_a is small:

$$\omega = \frac{V_a}{K_f I_f} \tag{2.10}$$

That is if the field current is kept constant, the speed motor depends on the supply voltage. These observation leads to the application of variable DC voltage to control the speed and torque of DC motor.

2.4 Speed Control DC Motor Using Microcontroller

The electric drive systems used in industrial applications are increasingly required to meet higher performance and reliability requirements. The DC motor is an attractive place of equipment in many industrial applications requiring variable speed and load characteristics due to its ease of controllability. Microcontrollers provide a suitable means of meeting these needs [3]. Certainly, part of the recent activity on microcontrollers can be ascribed to their newness and challenge. In this project use microcontroller as controller for the speed controller use PIC.

Another system that uses a microprocessor is reported in the work is reported in journal a brief description the system is as follow: The microprocessor computes the actual speed of the motor by sensing the terminal voltage and the current, it then compares the actual speed of the motor with the reference speed and generates a suitable control signal which is fed into triggering unit [3].

A simple form of speed control is achieved through a variable potentiometer for a manually controlled system; the operator mentally compares the actual speed to a desired speed and sets the potentiometer accordingly. A simple form of speed control is achieved through a variable potentiometer for a manually controlled system; the operator mentally compares the actual speed to a desired speed and sets the potentiometer accordingly. By comparing the speed in revolution per seconds (rps) updated on the CRT screen each second to a desired speed, he/she corrects the current speed by rotating the potentiometer clockwise to increase or counterclockwise to reduce, the speed [4].